

Planning Report No. 57

A CHLORIDE IMPACT STUDY FOR SOUTHEASTERN WISCONSIN

Chapter 1

INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

This Planning Report presents the major findings from the Chloride Impact Study (Study) developed by the Southeastern Wisconsin Regional Planning Commission (Commission or SEWRPC). This Study was initiated due to heightened public concern over the growing use of road salt and evidence of increasing chloride concentrations in surface water and groundwater in the Southeastern Wisconsin Region (Region). The detailed findings of this Study are presented in a series of Technical Reports as discussed below.

Chloride is predominantly found in the environment as chloride ions, or as a chloride salt attached to sodium, potassium, magnesium, or calcium. Chloride salts are highly soluble in water and are present in some concentration in all surface waters. Chloride is not decomposed, chemically altered, or removed from water as a result of natural processes. High chloride levels are toxic to aquatic organisms and plants; corrosive to roads, pipes, bridges, and cars; contaminate drinking water; and have negative human health impacts if ingested. As chloride is not naturally removed and is very expensive to mechanically remove once it is in surface waters and groundwater, the Study's goals focused on reducing the human sources of chloride to the environment.

1.2 NEED FOR THE STUDY

At a Regional Planning Commission meeting in March 2014, two Commissioners called attention to the growing public concern for environmental impacts of the use of salt in winter road maintenance. Public concern was focused on the effects on surface water and groundwater resources in the Region, particularly

for inland lakes. After further discussion, the Commission reached a consensus and directed staff to prepare a Prospectus for a comprehensive study of the environmental impacts of chloride in southeastern Wisconsin.

In 2016, a Prospectus for this Study was completed by Commission staff with input from a Technical Advisory Committee.¹ The Prospectus summarized the need for the Study, the scope of the work, along with a schedule and estimated costs to complete the Study.

Major observations in the Prospectus that supported the need for the Study included:

- Rising chloride concentrations in the inland lakes of the Region
- Rising chloride concentrations in streams of the Region
- In 2014 five streams in the Region were listed as impaired due to chloride concentrations exceeding Wisconsin's acute aquatic toxicity threshold
- Minimal winter chloride data available for surface waters in the Region
- No continuous monitoring of chloride in streams of the Region

Once the Prospectus was completed and approved by the Commission, funding for the Study was pursued and secured. Work began on the Study in 2017.

1.3 OVERVIEW OF THE STUDY

Major Study components included stream and lake monitoring, water quality analyses, and research efforts which are discussed in more detail below. The approximate timeline for these efforts was as follows.

- 2017: Pilot effort to select field monitoring equipment and determine a stream sensor installation setup for continuous monitoring that would survive winter conditions and ice effects
- 2018-2021: Stream and inland lake monitoring effort

¹ Prospectus for a Chloride Impact Study for the Southeastern Wisconsin Region, *SEWRPC, March 2016*.

- 2022-2026: Data cleaning and compilation; research, analysis, and development of the seven Technical Reports; and completion of this Planning Report

Stream and Lake Monitoring

Commission staff established a set of water quality monitoring sites in streams and lakes that were selected to be representative of the Region (see Map 1.1). The Study analysis area (study area) was expanded beyond the boundaries of the Region to include the upstream extent of the contributing drainage areas for streams flowing into the Region, as shown on Map 1.1. Water quality monitoring at the selected 41 stream locations included continuous collection of specific conductance (as a surrogate for chloride) using automated monitoring equipment. In addition, grab samples, which capture water quality conditions at a single point in time, were regularly collected for chemical analysis. Water quality monitoring at the six lake locations was performed seasonally and included collecting grab samples at several selected lake depths for chemical analysis. Additionally, specific conductance and temperature data were collected at multiple depths along a vertical profile at the deepest point of the lake.

The Study was designed to perform field monitoring and data collection for two years from October 2018 through October 2020, including two winter seasons. Grab sampling for the Study was completed monthly, during approximately the same week each month. Near the end of the two year sampling period it became apparent that monitoring would need to continue for a third winter season, with the goal of winter weather event sampling to capture extreme chloride conditions. Capturing the additional data was important for the development of regression equations, discussed below, which were used to convert the measured specific conductance to estimated in-stream chloride concentrations.

The Study monitoring effort is documented in SEWRPC Technical Report No. 61, *Field Monitoring and Data Collection for the Chloride Impact Study*, September 2024 (TR-61).

Water Quality Analyses

Water quality analyses included compiling and analyzing all available chloride and specific conductance data in streams, lakes, and groundwater; converting the Study's continuous stream monitoring data (collected as specific conductance levels) to chloride concentrations via regression models; calculating chloride loads for various sources within the study area; and performing a mass balance analysis to compare calculated chloride source loads to estimated chloride loads in select streams.

Chloride Conditions and Trends in Surface Waters and Groundwater

The Study evaluated the historical and existing chloride conditions, as well as trends in chloride concentrations in surface water and groundwater in the study area. This assessment was a culmination of extensive surface water and groundwater data from the 1960s through 2022 collected for a variety of purposes by an assortment of Federal, State, and local agencies; universities; nonprofit organizations; and citizen monitoring groups. Chloride data gathered during this time period included 2,665 lake samples from 116 lakes, 47,669 stream samples at 647 distinct stream monitoring stations, and 56,148 samples at 3,910 wells distributed throughout the study area. Many of these waterbody samples and well records were only taken periodically (some only once, monthly, and some seasonally for one or many years). Available specific conductance data were also compiled to supplement and help interpret the chloride data and trends where necessary.

Evaluations of historical chloride trends were made when sufficient data were available. The overarching goal of this effort was to determine the extent to which surface waters and groundwater in the study area have been impacted by chloride pollution and to what degree chloride conditions are improving, becoming worse, or remaining stable.

This work is documented in SEWRPC Technical Report No. 63, *Chloride Conditions and Trends in Southeastern Wisconsin*, **Month** 2026 (TR-63).

Regression Model Development for Converting Specific Conductance to Estimated Chloride

Regression models were developed for the Study to estimate the concentration of chloride in surface water from measurements of specific conductance. Solutions of many inorganic compounds, such as chloride salts, are relatively good conductors of electricity. Thus specific conductance, which gives a measure of dissolved solids in water, can act as a surrogate for measuring chloride once a relationship between the two is established. Commission staff used continuously collected specific conductance as a proxy for chloride concentrations, as conductance sensors are more robust and significantly less expensive than chloride probes. In addition, the availability of automated monitoring equipment for specific conductance enabled monitoring at much finer time scales (on the order of 5 minutes) than would be possible through grab sampling for chemical analysis.

Commission staff developed and refined regression models for predicting chloride concentration from specific conductance for portions of the Region. These models were developed using the simultaneous specific conductance and chloride data collected by Commission staff at the 41 stream and river sampling

stations in the study area over the period October 2018 through May 2021 (see Map 1.1). The models were used to estimate chloride concentrations from the nearly continuous specific conductance measurements collected as part of the Study.

This analysis is documented in SEWRPC Technical Report No. 64, *Regression Analysis of Specific Conductance and Chloride on Concentrations*, May 2024 (TR-64).

Chloride Source Loads

Commission staff quantified sources of chloride to the environment within the Region and larger study area using available data and information obtained from literature reviews. Chloride loads were estimated for several sources within the study area including road salt and other chloride-based compounds applied for anti-icing and deicing of public and private roads, sidewalks, and parking lots; water softeners and other domestic wastewater sources that are conveyed to public wastewater treatment facilities or private onsite wastewater treatment systems; industrial wastewater from sources such as chemical manufacturing or food processing; livestock manure and large agricultural feedlots; agricultural fertilizers and irrigation; and the atmospheric deposition of chloride.

Mass Balance Analysis

Commission staff also estimated the chloride source loads within the upstream contributing drainage areas at select Study stream monitoring sites to compare to in-stream chloride loads calculated at the site. The stream monitoring sites selected for analysis were located near existing U.S. Geological Survey stream gage stations to provide reliable streamflow data. In-stream chloride loads were developed using the streamflow data and chloride concentrations that were estimated from the specific conductance data collected as part of the water quality monitoring and regression model efforts discussed above.

The chloride source load calculations and mass balance analysis are documented in SEWRPC Technical Report No. 65, *Mass Balance Analysis for Chloride in Southeastern Wisconsin*, December 2025 (TR-65).

Research

Research efforts for the Study included documenting the impacts of chloride on the environment, summarizing the state-of-the-art options for chloride management, and compiling legal and policy considerations for managing chlorides.

Impacts of Chloride

This effort presented the results of an extensive review of the scientific and technical literature regarding the impacts of chloride and chloride salts on the natural and built environment. Impacts to surface waters and groundwater are discussed, including the consequences of higher chloride levels on the physical, chemical, and biological integrity of ecosystems, the structural integrity of infrastructure, and the health and well-being of people living and working within the Region and the broader study area.

The impacts of chloride are documented in SEWRPC Technical Report No. 62, *Impacts of Chloride on the Natural and Built Environment*, April 2024 (TR-62).

State of the Art for Chloride Management

Commission staff conducted a review of the technical literature regarding best management practices and state-of-the-art technologies aimed at reducing chloride inputs to the environment. Chloride management technologies and reduction strategies were summarized for public and private winter deicing, municipal water and wastewater utilities, private residential water softening systems, agricultural fertilizers and operations, and from industrial food processing (dairy, meat and poultry, fruits and vegetables). Where available, performance and cost information for the state-of-the-art technologies was included.

This work is documented in SEWRPC Technical Report No. 66, *State of the Art in Chloride Management*, **Month** 2026 (TR-66).

Legal and Policy Considerations

This effort included a review of legal and policy strategies for the management of chloride and provided a menu of responsive legal and policy options available to decision-makers in the Region.² These include limiting slip-and-fall liability, relying on direct regulatory authority such as the Clean Water Act or corresponding State regulations and municipal ordinances, disseminating relevant information to stakeholders and the public, using alternatives to chloride where feasible, leveraging new policy strategies such as water quality trading, investigating integrated watershed management across jurisdictions, and obtaining economic assistance. This work did not suggest that all of these options are appropriate in every context, nor did it attempt to rank them according to usefulness or feasibility. Those decisions were left to the affected communities.

² This work was led by Marquette University Law School Professor David Strifling and two of his students, Margaux Serrano and Ivy Becker.

This work is documented in SEWRPC Technical Report No. 67, *Legal and Policy Considerations for the Management of Chloride*, April 2024 (TR-67).

1.4 REPORT FORMAT AND ORGANIZATION

This Report summarizes the major findings of the Study and is organized into 10 chapters. Each subsequent Chapter begins with a list of the Study Technical Reports referenced within it. More detailed information on specific topics can be found in the referenced Technical Reports.

Following this introductory chapter, Chapter 2 describes the study area characteristics and climate conditions and trends. Chapter 3 describes the sources of chloride to the environment as well as results from the regional chloride budget and mass balance analyses. Chapter 4 outlines the impacts of chloride on the natural and built environment, including the physical environment (soils, groundwater, streams, lakes, and wetlands), the biological environment (fish, macroinvertebrates, and plants), infrastructure (steel and concrete structures, water supply systems, and cars), and humans.

Chapter 5 discusses State standards and guidelines for chloride in surface waters and groundwater. Chapter 6 reviews chloride conditions and trends from 1960 to 2022 in the streams, lakes, and groundwater of the Region. Chapter 7 describes options for future monitoring chloride in the natural environment. Chapter 8 discusses the most feasible and effective state-of-the-art technologies for managing sources of chloride to the environment.

Chapter 9 describes the potential future chloride conditions, both from a Regional development and growth perspective and considering potential future weather conditions. Chapter 9 also discusses alternative scenarios for chloride management under future conditions. And finally, Chapter 10 provides recommendations for reducing the impacts of chloride in the environment.

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MAPS

Map 1.1
Stream and Lake Monitoring Sites for the Chloride Impact Study

